INJURIES TO MUSCLES AND JOINTS AND THEIR TREATMENT BY GRADUATED CONTRACTIONS.

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by

I N T R O D U C T I O N.

Remarkably little consideration has been given in the past, and unfortunately is still given, by the Medical Profession to what is perhaps the commonest of all injuries, viz:- "Sprains of Joints and Muscles", and this, in spite of the fact that even the most simple and uncomplicated sprain of a joint or muscle, frequently, by wrong treatment or neglect gives rise to n an amount of crippling, out of all proportion to the apparent severity of the original injury.

It is difficult to understand why the Medical Profession has remained so blind to the serious consequences of sprains, as it must surely be the lot of every medical practitioner in his daily work to see the late results of this form of injury.

Yet no real action has been taken to advocate reform of treatment, or to devise some new method, except by a few surgeons who have gone one step in the right direction by condemning the principle of placing

injured joints at rest for long periods by splints, etc. - a method of treatment which is often as much the cause of permanent serious results as the injury itself.

Apparently, it has not been sufficiently realized that a joint, with its surrounding soft parts, is one of the most complicated structures in the body and that it is liable to frequent injury with varying degrees of inflammation, as a direct consequence to the constant use to which it is subjected.

As a joint is composed of many structures, bones with cartilage covering the ends, synovial membrane, ligaments, muscles , tendons and the loose connective tissue carrying blood vessels and nerves, all of which are necessary for the efficient action of the joint, the importance of inflammation which may attack and alter one or many of these structures, must be obvious. The method of treatment usually adopted for such a complicated structure when injured is, in by far the majority of cases, to subject the part to rest, blistering, hot or cold applications and all kinds of mechanical supports. Massage, passive and active movements are much more in vogue than formerly, and mark a distinct advance, but all too frequently the good effects that might accrue from massage, etc., are prevented or materially limited by the results to the joint of rest

usually advised for some time before commencing active treatment.

It is generally admitted that the results of these methods of treatment are very disappointing, yet no great effort has been made to improve upon them, probably because many cases do recover, at least partially, even in spite of the treatment adopted. But many cases of Sprain have in reality only partially recovered, although they are looked upon as "recovered", because for some inexplicable reason it is frequently assumed that a joint once injured must remain weak for ever afterwards, and because of this belief, many cases consider themselves "recovered", although a certain amount of disability remains.

By far the most common result, however, is that for years afterwards a joint which has been injured retains a general feeling of weakness and insecurity, and it cannot be trusted to obey the unconscious call of its owner with such certainty as was possible before the injury, and, although the Patient may be able to use it quite well for ordinary purposes, he always feels <u>conscious</u> that he has a joint, a condition which very seriously limits the use of his limb for anything but simple and slow movements.

Impressed by these facts, I commenced the serious

study of injuries to joints and muscles and their sequelæ, and for the past nine years I have occupied myself in the treatment of such cases by a method which I have devised and called "Graduated Contraction."

After treating many hundreds of cases of Sprains of every degree I am in a position to state that this method is, both for early and late cases, far superior in the completeness of its results, and much quicker in promoting recovery, than any method at present adopted.

In the present thesis, I shall describe this method of treatment, the special apparatus used, technique, the reasons for the results obtained, and the conclusions I have arrived at from so large an experience of such injuries.

DESCRIPTION OF METHOD AND EFFECTS PRODUCED.

The Graduated Muscular Contractions are obtained by a specially designed electric coil, a full description of which appears at the end of this thesis.

At the outset I wish to strongly emphasize the fact that although the Graduated Muscular Contractions are produced by means of an electric current, no virtue or curative power whatever is claimed from the use of electricity per se. Electricity is merely a means to an end, and is made use of as the stimulus which produces the exact degree of muscular contraction aimed at, and it is solely as a result of this contraction and relaxation with all the attendant chemical and circulatory changes that the desired results are obtained. The operator is enabled to cause alternate painless contraction and relaxation of the injured muscle or group of muscles, and the type of contraction produced so closely simulates the physiological contraction of a muscle, that the result is indistinguishable from a normal voluntary contraction.

The contraction produced is under the absolute control of the operator, and the rise and fall of the stimulus can be so accurately graduated that, starting

from zero, it may be gradually increased to the maximum contraction which the muscle acted upon is capable of without damage, and the muscle then allowed to relax just as gradually, or if necessary it may be held in a state of contraction.

The contraction thus produced is in no way a local spasm of part of the muscle as is produced by the usual medical faradic coil, but is a wave contraction of the entire length of the muscle. A single muscle, or a whole group of muscles, may be contracted and relaxed in this way. A healthy group of muscles when acted upon by such an apparatus can thus be made to contract and relax rhythmically, so as to cause painless reproduction of the movements of the joint upon which the particular group acts.

EFFECTS OF GRADUATED CONTRACTION ON MUSCLES.

When a muscle is strained, it loses its tone and becomes relaxed, slack, and lengthened, and consequently it acts at a great disadvantage and is unable to perform its function completely; the result of Graduated Contraction on a muscle in such a condition is that the muscle quickly regains its tone, and thus quickly recov-

ers its lost power to contract, and consequently its function returns. The physiological action due to muscular movement is reproduced, with the result that the relaxed muscle becomes contracted and shortened, absorption of effusion or blood clot is greatly promoted, circulation to the part is directly stimulated, chemical changes take place in the muscles, and above all, adhesions are prevented from forming owing to the movement of the muscles not allowing the organization of the lymph to take place between their surfaces; and if, as in the later stages adhesions have formed, they may be gently but effectively torn apart by carefully contracting the muscles separately. The breaking down of adhesions by this method, does not cause so much after effect as is the case in forcible rupture by manipulations, consequently there is less pain, and this fact is very important as the absence of pain allows the patient to obtain voluntary movements much sooner.

The method so quickly redevelops wasted muscle that a joint which has become very weak for may be many months or even years, shows a great increase of power in a few days, and this is quickly followed by obvious increase in the muscular tissue. This increase of power, which takes place much sooner than the increase in the muscular tissue, is due to the rapid recovery of the tone of the wasted muscle, and to the shortening of the muscle which allows it to act on the joint with greater

advantage. Such increase of power is of supreme importance as it gives a sensation of security to the joint which encourages the patient to use the part in a better manner, and thus the stimulation of the recovering muscles is kept up with beneficial effect.

Before discussing the particular cases which are suitable to treatment by Graduated Contraction it would be as well to describe what happens to a muscle when strained, and the reasons of the many serious consequences of such a condition.

The words "Strain" and "Sprain" are, as a rule, somewhat indiscriminately applied to any injury of a muscle or a joint, so that I am in the habit of using the word "Strain" with reference to muscle alone, and the word "Sprain" as applicable to an injury of a joint where structures other than the muscles are affected.

As the result of a strain depends of necessity on the degree of violence which causes it, and depending on this, the effect may be injury of one or more of the component parts of a joint, it will perhaps be easier to describe the results of a slight and severe strain to the muscular part of a joint generally and later describe the effects of injury to the other structures.

A muscle when physiologically fit even when at rest, is in a state of slight contraction which is known as "muscle tone", and this tone allows a muscle to be in a state of preparedness to respond to any

sudden stimulus, the resulting contraction being to cause movement or support of the joint upon which the muscle normally acts.

When a muscle is strained this condition of tone is at once altered, and the muscle becomes relaxed and more or less inflamed. The immediate effect of the relaxation is that the muscle becomes relatively longer and so incapable of complete contraction. This causes impairment of the action of the joint, because the other muscles which control the movement of the joint act at a disadvantage as one of their number is thrown out of action.

The joint is thus affected in two ways:-

(1) By the original muscular strain putting the muscle out of action, partially or wholly.

(2) By the excessive strain caused to the other muscles due to their having to work at a disadvantage without their fellow.

The great importance of this condition of impairment is, that if recovery does not take place soon, the joint becomes further crippled owing to muscular wasting, the formation of adhesions and the laxity of the joint caused by the absence of the normal muscular tone.

The seriousness of this condition is due to the after effects, and it is no uncommon history to have months of disability and pain as the result of a simple

strain, the late effects of which could have been prevented by properly treating the condition from the first. Here it is as well to emphasize that the advice so commonly given to rest the part for this condition constitutes improper treatment, and much too frequently the more serious results follow such a simple injury owing to prolonged rest being advised.

The injured muscle is relaxed and has lost its physiological tone, and, as this relaxation and loss of tone is the chief cause of its disability, the object of any treatment should be to devise some method of causing the muscle to regain its tone and hence its original length, so that it may again work on an equality with the other muscles of the joint. This result can to a certain extent be obtained by massage and passive movements, but the end can be achieved much more quickly and completely by this method of Graduated Contractions.

The great difference between massage and passive movements and the method of Graduated Contractions, is, that by the former two methods the beneficial results are secondary to the stimulation of the circulation promoting absorption, whereas by the latter method the good results are due to the direct stimulation of the muscles causing them to exercise their function viz; physiological contraction with all the natural changes

dependent on such contraction, and the mechanical effects due to the direct movement of the joint.

When a joint - such as the wrist - is moved by passive movements in all its directions, the result cannot compare with that obtained by moving the joint by Graduated Contraction of the muscles which functionate the joint, as in the latter case, the action of the muscles themselves is the direct cause of the joint movement, and this actual movement of the muscles and tendons prevents them from remaining in contact long enough for adhesions to form. Further by the contraction of a group of muscles the blood is squeezed out of the muscles at each contraction and passed into the venous system and arterial blood rushes into the muscle on relaxation, to be again forced onwards at the next contraction, this action being a powerful method of stimulating the circulation through the injured structures.

SEVERE STRAIN OF A MUSCLE OR GROUP OF MUSCLES.

When a group of muscles is severely strained the actual condition produced is a subcutaneous wound of more or less severity. The immediate result is that the patient, anxious to get relief from pain, places

the part in the position of greatest ease, and therefore when adhesions form the result is restriction of movement in the opposite direction. To effect repair of this subcutaneous wound coagulable lymph is poured out and this speedily becomes organised exactly as would happen in the repair of an aseptic wound. If a large amount of lymph is poured out, and there be much extravasation of blood, the result of the organisation is that adhesions are formed, which are always very sensitive, so that they restrict the action of the part for two reasons, because of the pain caused by the stretching of the adhesions on any attempt at movement, and because of the union of the fibrous tissue to the neighbouring parts causing more or less fixation.

As the pain causes the patient in the first instance to place the muscles in the position of greatest ease, the adhesions may bind the tissue in a very irregular way, so that the muscles must act under a great disadvantage, and this condition is one of the most frequent causes of serious disability from pain and interference with function.

SPRAINS OF JOINTS.

In considering the results of violence on joints, it must be remembered that one or more parts of the joint may suffer primarily or be the seat of serious hurt as the result of the changes concomitant to the original injury. For example, the ligaments and capsule may be injured, causing secondary changes from effusion, extravasation of blood, and inflammation in the synovial membrane and the loose cellular tissue surrounding the joint, these changes leading to adhesions and matting together of important structures, thus causing serious limitation of the movements of the joint. When a joint is sprained the muscles round the joint are always injured to some extent from a slight strain to actual tearing, as the reason of the injury to the other structures of the joint is due to the fact that the muscles controlling it have been taken unawares, or are relaxed from fatigue or weakness due to some cause, such as unfitness, or wasting from some former injury.

It has been said of dislocations that it is only possible for them to take place when the muscles are unable to perform their function, from any cause, and this is even more true in the production of sprains of joints, as the injury to the other parts of the joint is the result of the violence having first overcome the muscles.

It is for this reason that in all injuries to the joints, the surrounding muscle is primarily injured to a more or less degree.

In every case of sprain, no matter how slight, effusion and hæmorrhage into the tissues always take place, and consequently the injury is not confined to the moment of the accident. The blood pours out from the torn blood vessels, and collects in the joint and the cellular tissue around it, the tension of which is the cause of the pain, and the stretching of the parts leaves the capsule and ligaments loose and flaccid after absorption has taken place, the result of which is that the joint remains loose and is left in a state in which it is liable to further injury from slight causes. When absorption does not take place, organisation results and the parts become matted together, thus greatly limiting the movement of the joint, interfering with the circulation and pressing on the nerves and so causing secondary changes in the various structures of more or less severity. Thus an injury to a joint although primarily affecting one structure - such as the capsule - frequently ultimately results in serious secondary changes in any of the other structures.

The ligaments - which are frequently torn across as the result of violence - are chiefly concerned in limiting the movement of a joint in certain directions.

and the integrity of a joint depends principally on the condition of fitness of the muscles which surround and act upon it, and not to any great extent on the degree of tightness of the ligaments which reinforce its capsule.

A good example is that of the shoulder joint which is a joint capable of wide movements in all directions, and in which the capsule is very loose and the muscles take the place of the ligaments and are the chief means of controlling and restraining the movements.

This emphasizes the great advantage of using a method of treatment which acts directly on the muscles to encourage them to recover their muscle tone, and which, by stimulating them to contract, promotes the physiological changes resulting from muscular action.

As the knee joints is one of the commonest joints - probably second in frequency to the ankle - to receive injury, the degree of injury varying from a slight strain to acute synovitis or displaced semilunar cartilage, I think it well to here give a short description of a common knee injury.

I have already pointed out the reasons that when a joint is sprained, the muscles are always affected and that, whatever structure is injured as the direct result of the violence producing the sprain, any other struc-

ture may be damaged by secondary changes supervening.

The most commonly inuured structure is the soft vascular tissue which is contained in the spaces between the component parts of the joint, and this tissue may be badly crushed and bruised, resulting in extravasation of blood into the cellular tissue, tendon sheaths, or synovial cavity.

But whether the injury be slight or serious, the most important fact to bear in mind is that in all cases one of the chief results of injury to the joint is the loss of tone to the surrounding muscles and their consequent slackening" and ultimate wasting. This state of affairs follows an injury such as a sprain, but it may also be the result of inflammation in a joint produced by any cause, i.e. when a joint is inflamed the muscles which actuate that joint, more particularly the extensors,lose their tone, and become "slack", and rapidly waste. In the case of such a condition supervening on an injury to a knee joint, the weakness of the muscles causes the patient to feel shaky about the knee, and he soon begins to find difficulty in using the joint for the most ordinary movements, and this disability is increased in proportion to the wasting of the muscles. The immediate result of this slackness and weakness of the muscles is to allow the knee joint to become so

loose that the upper articular surface, as the result of a sudden movement, actually slips laterally over the lower articular surface, particularly when the knee is slightly flexed. This slipping causes sudden pain, and if the synovial membrane becomes pinched, synovial effusion supervenes. Such a sudden slip may also cause displacement or fracture of a cartilage. As the result of the examination of a large number of knees which are in a condition as above described, I am firmly of opinion that many such cases are diagnosed as displaced or loose semilunar cartilage, all the symptoms of which are in reality due to this sudden slipping of the articular surfaces and pinching of synovial membrane, and would be easily remedied by tightening up the joint by causing the surrounding muscles to regain their tone.

If a normal joint has a severe stress applied to it, and the muscles are sufficiently strong and act quickly enough to overcome this stress, no damage is done beyond perhaps a slight strain to some muscular fibres which soon recover. If however, the muscles are unable to overcome the stress, either on account of insufficient strength or by being taken unawares, the result will be that the muscles are more severely strained causing rupture of their fibres, effusion of

fluid, and hæmorrhage. The synovial membrane may be badly damaged or a cartilage (as in the knee) may be dislocated or fractured.

In the case of the knee the immediate result is that the muscles become so relaxed that the articular surfaces, instead of being held in close apposition by virtue of the tone of the surrounding muscles, become unduly separated, and, as the slackness of the joint increases as the muscles waste, the joint is in a condition to allow of dislocation of the semilunar cartilage by the slightest movement, if it has not already been displaced. It is on account of this increasing looseness of the joint that repeated dislocation of the semilunar cartilage takes place, and if when a cartilage is displaced for the first time it is speedily reduced and the surrounding muscles brought back to perfect physiological condition by Graduated Contractions, the result is considerable tightening of the joint and the dislocation of the cartilage becomes difficult to produce again, and many cases which I have so treated have never recurred.

In addition to the results already described, a sprain may be complicated by ligaments being torn across or from their attachment to the bone, or the bone itself may be broken off at the point of attachment of the

ligament. Tendons may be actually displaced, and fractures and dislocations of small bones may result.

As it is obviously of the utmost importance that the extent of any injury should be accurately diagnosed if a successful issue is to be expected from any form of treatment, I cannot emphasize too strongly the importance of Radiography. I have been astounded at the large number of cases about which I have been consulted as the result of "sprains which have not recovered", and which on examination have proved to have been fractures. The majority of such cases are so-called "sprained" ankles, and next in frequency is the wrist joint, followed by the shoulder joint. I am well aware that it is impracticable to X-ray all cases of injury, but I am frequently informed that the medical attendant advised that the X-ray examination was not necessary "because there was no fracture". It is precisely when that is the opinion that the X-rays should be utilised if possible, because if there be a fracture as is so often the case, the result of treatment when none is suspected may be and generally is disastrous.

While on the question of the use of X-rays, it may be as well to point out what apparently is not commonly known, and that is, that a fracture may be present which is not visible to the eye when the part is

examined by the screen alone, but which is clearly visible when a negative of the part is taken.

Stereoscopic X-ray photography is of the utmost importance - and in fact is essential - in examining the carpus and tarsus for probable fractures or dislocations which are by no means uncommon injuries. I have three cases on record of dislocation of the semilunar in the wrist, and several of fractures of tarsal and carpal bones, which were not diagnosed when examined by a non-stereoscopic negative. I have recently seen a case of injury to a wrist which was examined by the X-rays in the usual way and the diagnosis made that the styloid process of the ulna was fractured. Three months after the accident, I had the wrist stereoscopically X-rayed and it was then clearly seen that the scaphoid was fractured, and that all the bones of the carpus with the exception of the semilunar were displaced backwards.

EFFECTS OF INJURY TO A JOINT.

I have attempted to show that when a joint becomes sprained, the injury takes place to the muscle in the first place and is produced by the great effort

made by the muscles themselves in their endeavour to prevent the effect of stress applied to them injuring the joint, i.e. the muscles counteract the stress and if the stress is sufficiently powerful to overcome the action of the muscles, injury varying in degree takes place to the various structures of the joint. The result is that the muscles become strained so that the force applied to the other structures of the joint may primarily affect, by crushing or tearing, one or several structures, such as the loose connective tissue, the synovial membrane, the capsule, the ligaments, bursæ, cartilage, and even the bone. Even in slight injuries the soft vascular tissue which fills the spaces of all joints is frequently torn or pinched, and this, because of the later changes, is of the gravest importance. Hæmorrhage takes place into this loose tissue, and collects in the various parts of the joint - in the tissue itself, synovial cavity, tendon sheaths, and between the contiguous tendons and muscles. When complete repair takes place, this extravasated blood is absorbed and little harm results, but if the absorption is not complete, organisation takes place and adhesions form in various parts, and the joint becomes seriously limited in action from the actual adhesions causing fixation and from the pain produced by stretching the adhesions on attempted movement. Owing to the pain,

the injured joint is kept at rest in the position of greatest ease, and owing to the great relaxation of the strained muscles, the power of voluntary action is more or less lost, and the inability to move the joint becomes greater. Thus even when the pain becomes less, the joint is still greatly restricted in action, and contiguous structures gradually become more adherent to each other with disastrous results to the function of the joint.

I am convinced that adhesions form rapidly, and much more frequently than is generally believed in the various bursæ, and that in consequence, although not greatly restricting the movement of the joint, a certain amount of stiffness and pain results because of the lost function of the bursæ which is to diminish friction. Besides actual adhesions in the bursæ, the walls of the sac become easily thickened, and the seat of constant pain and tenderness - a condition very frequently met with in practice.

Repair.

In attacking the question of what method of treatment to adopt to aid recovery to an injured joint, it must be borne in mind that many of the symptoms of injury are the result of the efforts of Nature to counteract the damage - swelling, heat, redness, etc. But

unfortunately, although the conditions producing these symptoms are necessary for repair, they at the same time are the cause of severe damage to the function of the injured structure, if for any reason, absorption does not take place completely, or contiguous parts remain too long at rest so that adhesions form between their surfaces. Therefore the most ideal method of promoting reparative changes and lessening the chance of adhesions is a method which will stimulate absorption and at the same time keep the parts on the move which are liable to become adherent to each other. This double action is precisely what is claimed for the method of Graduated Contraction. The tendons and joint surfaces are moved from a slight degree to a wide range of movement at the will of the operator, with the result that the surfaces are not allowed to remain in contact with each other, and, by the alternate contraction and relaxation of the muscles, the circulation is greatly stimulated, absorption thus being rapidly promoted. It may be definitely stated that in injuries to soft tissues, the most important factors in determining recovery are the amount of bleeding produced and the rapidity with which absorption takes place.

When the complexity and variety of structures which go to form a joint are considered, and the changes resulting from the pouring out of blood and lymph into

these structures is realized, it is not difficult to recognise that the result of injury to a joint affects the various structures differently and in various degrees. After the straining of the muscles, the first structures to become affected are the blood vessels, which, besides being torn, become greatly dilated, and, in consequence, a larger volume of blood at first flows through the injured area, and reparative lymph pours out into the tissues. This condition gives rise to increase of temperature to the part. The lymph mixes with blood which has escaped from vessels which have been torn, and consequently swelling varying in degree takes place from the accumulation of this fluid in the synovial cavity, bursæ, tendon sheaths, muscles and the loose tissue which fills up the interstices between these structures. The amount of swelling of each structure is governed by the relative density of their textures. The chief result of all these changes is that the joint becomes painful, and this pain is increased by movement.

This fact has probably been one of the determining factors in the adoption of Rest by splints, etc., as a common method of treatment of such injuries. I have heard it argued in defending the treatment by rest that the muscles which functionate the joint are

reflexly relaxed and so partially lose their function - this being pointed out as Nature's method for causing rest to the part. In my opinion the cause of the muscular relaxation is direct injury to the muscles, and they are the first structures to suffer injury because the stress which injures the other tissues must first overcome the resistance of the muscles.

The treatment by Rest is only palliative, as it certainly relieves pain, but surely this is a small matter when the disastrous results which must follow are realized, - results which must be easily understood when the changes in the tissues which follow the injury are considered. By keeping such an injured part at rest, absorption is not sufficiently stimulated. The process of absorption is inclined to be less active, the various structures become stretched by the tension and so remain relaxed for a long time, and organisation takes place with the result that muscles and tendons become matted together, causing varying degrees of limitation of movement. The increased tension remains for a long time, and by compression of the blood vessels causes a diminished flow of blood to the part, which still further slows the process of absorption, and this depletion of blood may possibly be to some extent responsible for such changes in the bones as

traumatic osteoarthritis.+ Muscular wasting from disuse occurs and, as is frequently seen by radiography, rarification of the bones also supervenes. In spite of Rest, absorption may ultimately proceed, although slowly, and the flow of blood to the part gradually increases, but is again frequently hindered by tight bandaging which is so often advised in conjunction with Rest.

Even when a joint has been injured and no treatment is adopted to aid recovery it is manifest that active changes take place up to a certain point; but, chiefly because the part is kept at rest, owing to pain and muscular insufficiency and to the treatment so frequently advised, the complications above described result, and convalescence becomes delayed. The pain gradually decreases but the action of the joint becomes permanently interfered with from the organisation of the lymph in the injured tissues, and from muscular wasting. The thickened synovial membrane can be easily felt in a joint which has incompletely recovered, and the capsule and ligaments remain relaxed from the prolonged stretching, and consequently the joint becomes

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+ The pressure also affects the nerves to the joint and this effect may also contribute to the bony changes.

weak and insecure and in this condition is unable to withstand even slight stresses and so becomes easily sprained again from slight causes.

The degree of injury to a joint, must of necessity govern the time necessary to repair, and a joint in which the ligaments, tendons, or muscles are torn, must require a longer time than is necessary when these complications do not arise; the time of recovery even under the most ideal method of treatment must also vary in individual cases. However, whatever the normal time of recovery is considered to be, if continued rest to the part be adopted as the mainstay of treatment, this time will be greatly lengthened and complications promoted in every case, and more important still the gravest danger may result - viz. limitation of movement in the joint from the formation of adhesions.

It has frequently been argued by supporters of the method of treatment of injured joints by Rest that even severely injured joints do recover when so treated Undoubtedly in certain cases recovery does take place, but the time required is excessive, and before complete recovery can be claimed, the unfortunate patient has to spend a long time in undergoing treatment to overcome the <u>results</u> of the Rest treatment, viz, breaking down of adhesions and re-development of wasted muscles.

COMPARISON BETWEEN TREATMENT BY GRADUATED CONTRACTION AND OTHER METHODS.

In making a comparison between the treatment of sprains of joints by Graduated Contraction and other methods which are commonly employed, it is as well to discuss the effects to the injured structures resulting from these methods.

The treatments most commonly employed are, the application of Cold, Heat, Pressure, Massage and Passive movements.

Cold.

Cold acts by stimulating the blood vessels to contract and so tends to limit the bleeding and effusion. By so doing the pressure on the joint structures is reduced and the amount of pain due to such pressure is relieved. The vitality of the part must in consequence be to some extent reduced, and in any case, it is obvious that the value of this method, if valuable at all, is completely lost if not applied before the bleeding and effusion, which follows an injury almost immediately, has taken place.

The action of cold is entirely mechanical, and

although the dilatation which follows the contraction of the blood vessels is said to have a beneficial effect on the injured structures, I claim that the effect must be very slight unless the increased amount of blood is encouraged to leave the part and not become stagnant which it tends to do, after cold applications.

Heat.

Heat is applied to an injured joint also with the intention of limiting the amount of bleeding, on the well known principle that hot water tends to limit hæmorrhage, if the temperature be sufficiently high. I do not believe that this action does take place unless the heat comes in direct contact to the bleeding points, and it seems to me impossible that heat applied to the surface of a joint can have this action. Heat certainly does relieve pain but this action is probably reflex and not due to relief of pressure in the joint as in the case of cold. I believe the application of Heat acts beneficially by causing dilatation of the blood vessels and so increasing the amount of blood to the part, and if this increased amount of blood were further encouraged by gentle massage to circulate through the injured structures, the beneficial effect would be much greater than that resulting from the application of Cold.

Pressure

The application of pressure, if properly carried out controls hyperæmia and thereby tends to limit bleeding and effusion, with the consequent relief of pain. This action like that of cold, is also entirely mechanical.

Massage and Passive Movements.

By the application of skilled massage and passive movements, an injured joint is in my opinion being treated in a much more natural and scientific manner than by the application of cold, heat, or pressure, the value of which is chiefly the mechanical relief of pain. Massage, however, not only relieves pain mechanically and reflexly, but also increases the flow of blood to the part, promotes absorption, and tends to prevent stagnation in the tissues. It is by preventing stagnation in the tissues although the flow of blood is increased, that massage mechanically relieves pain, because pressure is reduced and extravasated blood becomes broken up and dispersed. Passive movements are adopted with the object of not allowing contiguous parts to remain in apposition to each other, and so the lymph on their surfaces does not organise and cause these surfaces to become adherent.

While admitting that cold, heat and pressure relieve the pain of an injured joint, I do not agree with these methods of treatment, because I do not think recovery is properly aided by means which restrict the amount of effusion by limiting the amount of blood which flows to the part, or which increases the flow of blood to the part unless means be taken to prevent stagnation. In my opinion if injured joints were treated more frequently by means which increased the amount of blood to the part, but which at the same time aided removal of this blood, thus preventing stagnation, the results of treatment of such injuries would be much better than they have been in the past, and complications such as stiff joints and wasted muscles would not supervene.

Although massage is far superior to cold, heat and pressure, because of the fact that the flow of blood is increased, with all its consequent results such as increased absorption, etc., I hope to show that the method of Graduated Contraction is just as superior to massage.

In the treatment of a sprain of a joint by Graduated Contraction, the joint is not directly treated, but the method is applied to the muscles which functionate the joint and the beneficial effect to the joint is

due to the changes which result from it being made to perform its function in a natural manner, and without pain.

Take for example a severely sprained wrist joint. Nothing is done directly to the joint to prevent bleeding or effusion, but as soon after the injury, Graduated Contraction of the flexors and extensors are produced, commencing by producing very slight contractions which have the effect of very slightly moving the joint in all directions, and, by the end of half an hour or so, the range of movements in all directions is increased, and these movements are well borne by the patient. The result on the joint is that the circulation through it is greatly increased, but is not allowed to stagnate, absorption takes place actively, pain is relieved, the tendons of all contiguous parts of the joint are kept moving, and the muscles of the fore-arm are prevented from losing their tone and so do not waste and lose their function. The increased flow of blood is produced by the blood being forced out of the muscles of the forearm by each contraction, fresh arterial blood then taking the place of this expressed blood at each relaxation, and at the same time the pressure of the blood at each succeeding contraction forces the circulation through the joint so that waste products quickly get removed into the general circulation.

When a joint has been injured, it would recover much more quickly if it could continue to reproduce its natural function, which is movement, so that all the vital changes resulting from exercise could be promoted, the most important being circulatory. But, on account of the various reasons already explained an injured joint is unable to perform its function. By Graduated Contractions, however, one is enabled to painlessly force the joint to perform its function in a natural manner commencing gradually and working slowly but surely to a maximum movement, and thereby all the beneficial circulatory changes are reproduced; obviously the sooner this process is commenced after the injury, the better, as thereby secondary results, such as adhesions and wasting of the muscles are prevented.

The treatment is carried out without any aid from the patient who remains perfectly passive and endeavours to keep the part undergoing treatment absolutely relaxed. (See Technique). The relief to the patient after treatment is frequently so marked that he quickly realizes that he is again becoming conscious of returning voluntary power over the injured joint, and this feeling of power encourages him to make efforts to move the joint, which efforts are of further benefit in promoting the changes necessary to repair.

When a joint is injured even when the injury is slight, a feeling of helplessness in the injured limb varying in degree and also varying in individuals, quickly supervenes. For various reasons a patient also becomes conscious of a joint when it is injured. These two sensations of helplessness and consciousness of the injured part are of the utmost importance, as they further contribute to the reasons why a patient will keep an injured part at rest. It is a common occurrence to find that a patient, who has had some injury to a joint which has recovered, or is well on the way to recovery, is, owing to these sensations, unable to functionate the limb properly, so that certain muscles are not stimulated to work, and they gradually waste and the power to enervate them becomes diminished. This feeling of consciousness and helplessness of the injured part increases in degree when the part is rested, and I consider these sensations due chiefly to loss of tone in the muscles. By stimulating the muscles to perform their function, as in treatment by Graduated Contraction, these sensations are rapidly lost, and the increased tone which quickly follows the stimulation, gives the patient a feeling of security, and he is thus encouraged to perform voluntary movements. The importance of this is evident

when it is remembered how frequently one sees injured joints which have completely recovered from the injury, except that some muscle or muscles are inefficient from wasting, and the loss of power to enervate them. In such cases the joint is being used wrongly by other muscles taking on the work of the inefficient ones, and such a joint is frequently the seat of further injury from slight causes, because the weak muscles, on any sudden emergency, are taken unawares.

Graduated Contractions, besides acting on the circulation, have also the important action of quickly restoring the patient's power to use the muscles, and in this way encouraging the synchronous action of the groups of muscles necessary to reproduce the normal movements of the joint, thus materially hastening recovery. Muscular wasting is prevented, and the movement of the muscles causes more or less deep massage to the joint structures, and in this way further aids absorption and prevents adhesions. It might be supposed that the movements caused by Graduated Contractions, and which I strongly advocate as soon after the injury as possible, might set up inflammation in the injured structures. After the experience of the treatment by this method of some thousands of cases, I am able to state most emphatically that there is absolutely

no fear of inflammation supervening as the result of such treatment. In fact, in my opinion, the muscular contractions, by decreasing the tension from blood or other fluid collecting in the synovial spaces or surrounding tissues, and so preventing stagnation, greatly reduces the possibility of inflammation, even in cases which from some constitutional condition, inflammation might be expected to result in a severely injured part.

The use of starch bandages and other supports should not be used for sprained joints, except under the most special circumstances, and if they have to be used for any reason, the muscles should be moved every day by Graduated Contractions, otherwise one or other of the complications due to rest of an injured joint will undoubtedly supervene.

An elastic bandage which is so often advised is perhaps the most pernicious form of support that could possibly be devised. It undoubtedly gives to a weak joint a feeling of comfort and support, and thus enables a patient to use an injured joint when otherwise he would say he was unable to do so. The support is much more mental than actual, and the patient is thus encouraged to use the joint owing to the mental effect of feeling that it is compressed, but, because the muscles are supported, they shirk their work to a great extent and gradually become more relaxed and wasted.

The nutrition of the muscles and tissues becomes interfered with from the diminution of the blood supply from the compression, and the joint becomes weak and loose and even more insecure, and a point is ultimately reached, when the muscles become so relaxed and wasted, that no amount of voluntary exercise will stimulate them to recover to their original size, and such muscles must be mechanically stimulated before they will recover. The wearer at first becomes accustomed to the support and so is apprehensive without it, and a joint in this condition becomes easily subject to injury from very slight causes. Such a joint may become so loose that even a sudden slight movement may result in sudden pain and effusion from pinching of the synovial membrane or the soft tissues of the joint, which have become hypertrophied.

Muscles may waste to a very great degree from disuse and many other causes, and, they frequently reach such a degree of wasting, that no amount of voluntary exercise even combined with skilled massage, will produce complete redevelopment.

With a muscle or group of muscles in such a condition, it is obvious that the joint, which such muscles should normally functionate, is working at a great disadvantage. I do not think the seriousness of such a

condition has been sufficiently realized. Lane[1] has pointed out that the form and structure of a joint remains normal only as long as the mode of transmission of a force through it remains normal, and any alteration in these lines of force transmission is followed by changes in the joint structure; so that in fracture of a long bone when union is such that the axis does not correspond with the axis of the other, the mechanics of the joint formed by the ends of the bones are changed from the normal by the influence of this alteration in the lines of force. While this is true as the result of fracture, it is equally the result of wrong transmission of lines of force through a joint resulting from limited or improper use of a muscle or group of muscles. The importance of this is, that this wrong transmission of lines of force through a joint, causes undue pressure on parts of the opposing surfaces of the articular cartilage, so leading to serious and permanent joint damage.

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(1) Lectures on "Treatment of Simple Fractures by operation", by Sir Arbuthnot Lane.

DESCRIPTION OF COIL USED TO PRODUCE GRADUATED CONTRACTIONS.

The Apparatus consists of two parts - the coil and the interrupter. The Coil is wound on the same principle as other faradic coils but differs in two important points namely, that the voltage of the current obtained from the secondary varies between 12 and 15 instead of being about 60, and the interrupter is entirely separate from the coil.

The primary winding consists of three layers of No. 18 wire and is wound round a central core $\frac{3}{4}$" in size. Over this primary is wound seven layers of No. 32 wire, which forms the secondary winding, the current from which produces the painless muscular contractions. A crank may be so arranged as to allow the use of one layer of the primary alone or two or three in series, thus exhibiting a higher inductive effect, and therefore a higher voltage from the secondary if desired. One or two dry cells according to the output required act as the source of energy.

An iron core consisting of bundles of soft iron wires fits into the central core round which the primary and secondary wires are wound, and has sufficient play

in the core to allow of its being moved easily in and out.

This iron core for ease of handling is placed about 2" above the base of the Coil.

The interrupter, which is a separate part of the coil, works on the Wagner hammer principle. A large piece of soft iron is attached to the end of a steel spring which touches a contact screw in the middle, and this piece of soft iron is poised on an arm, to which it is firmly fixed, above an electro-magnet. On closing the current the electro-magnet becomes magnetic and attracts the iron. This attraction draws the spring away from the contact screw and the current is consequently broken. The magnet, becoming demagnetised immediately the current is broken releases the iron, which by the pull of the steel spring, flies back and the same cycle of actions is repeated.

The wire leading from one of the terminals of the secondary winding is attached to a large flat electrode, and another wire leading from the other secondary terminal is attached to a small round electrode. The variations of the current are produced by moving inwards and outwards the soft iron core and by this means the degree of muscular contractions can be accurately controlled.

Careful construction of the interrupter is neces-

sary to avoid irregularities in working. If the latter should occur a painful sensation is at once produced instead of the otherwise painless muscular contractions, and the contractions become spasmodic and varying in degree. A condenser may be put across the poles and any irregularity which takes place at the point of contact is removed or considerably minimised.

The contractions produced in muscles by a skilled operator with the apparatus above described are painless, and can be controlled so accurately that the muscle is forced to contract from the slightest degree to the maximum contraction of which it is capable. The contraction produced is not in the nature of a local spasm of the muscle, such as is usually obtained from the ordinary faradic coil, but it is a wave length contraction of the whole length of the muscle, exactly simulating a voluntary contraction. The control is so perfectly graduated, that it is possible when acting on the facial muscles to painlessly reproduce the action of smiling, sneering, frowning, or winking, by stimulation of the groups of muscles which normally produce these expressions.

T E C H N I Q U E.

The following description is that of the actual technique which I am in the habit of applying and which has proved itself to be most efficient. It may, of course, be varied to suit the requirements of any particular circumstance or case.

The patient sits or lies on a couch 2 feet 6 inches from the ground and the operator sits facing him on a chair on the left hand side of the couch with the table upon which is the coil conveniently situated in front of him.

One terminal, which comes from the secondary winding, is attached to the indifferent electrode, a plain tin or zinc plate 6" x 4" covered with a soft "elephant's ear" sponge or several layers of lint soaked in warm water. This electrode is placed in any convenient part e.g. between the scapulæ in treating the upper extremity, under the knee or in the lumbar region when treating the lower extremity. This electrode should be firmly held in position by any means which ensures accurate contact to the surface to which it is applied.

The active electrode (which is also led from

the secondary winding), consisting of a small copper disc about one inch in diameter, is similarly covered and is firmly grasped in the cleft between the thumb and forefinger of the operator's left hand.

The operator uses his right hand to control the central core of the coil, the manipulations of which control the amount of stimulus.

The core controlled by the right hand must be fully withdrawn before the active electrode is placed in contact with the muscle, and when contact is made, there should be no contraction of the muscle with the core in this position, only a slight tingling sensation being felt. When the coil is set in motion, the left hand which holds the active electrode, grasps the muscle to be stimulated and presses the electrode on to it to make a firm contact. Then, with the right hand, the core is inserted and withdrawn at any desired rate, and the left hand is at once able to gauge the amount of contraction taking place in the stimulated muscle. With practice the operator becomes remarkably sensitive to the slightest variations in the stimulated muscles and consequently there is no fear of causing pain or damage by over contraction. If a muscle be over contracted, immediate pain is caused and severe cramp may supervene some hours later. The part of

the muscle which gives the best stimulation varies slightly in different patients but is readily determined in each case, when practice has made one expert.

The amount of contraction is under such perfect control that from the very slightest movement it can be gradually increased to the maximal contraction of which the muscle is capable and as gradually relaxed to a state of rest again. The joint on which a group of muscles acts, is moved in just as gradual a way, and the rate of succeeding contractions and the degree of the contractions is entirely under the control of the operator, depending on the rate at which he inserts and withdraws the core.

After considerable experience of handling muscles one becomes remarkably expert at interpreting the characteristic "feel" of muscles in various states of fitness - even a muscle which is in a state of slight strain has a characteristic "feel" to the touch.

A muscle should not be contracted too often continuously, and experience teaches the left hand to accurately gauge when a muscle being acted upon is showing signs of excessive stimulation. Such a muscle should be left at rest for a few minutes while another group is being contracted, and then again contracted, up to a point, without harm, so that it is always advisable to keep moving from one point to

another during the time the treatment is being applied.

A point of great practical importance is the necessity of making the patient understand that it is essential that he should be in a state of as complete relaxation as possible. It is surprising how the power of relaxing the muscles varies in different people, and the difficulty is obviously increased when a part is injured. It frequently requires considerable patience to coax a patient to relax the muscles, but it is a power soon acquired when confidence has been gained that the movements of the muscles do not cause pain. No current sufficient to cause a contraction should be allowed to pass through a muscle if the muscle be voluntarily moved or is being held in a state of tension, otherwise pain may supervene later. or at the moment of contraction.

Muscles which have been overstimulated, or stimulated with the coil when in a state of voluntary contraction, become stiff and painful some hours later, although they may feel quite comfortable immediately after being treated.

The active electrode must not be altered in position except when the core is fully withdrawn otherwise a painful stimulus will be produced. It is obviously impossible to lay down hard and fast rules for the duration of treatment as this can only be

determined by the condition of the muscles in each particular case. In a general way it is advisable to treat the muscles once daily, each treatment lasting roughly from ten minutes to half an hour according to:-

(1) The Pathological condition of the muscles.

(2) The particular muscle or group affected - a large group such as the quadriceps being more able to withstand prolonged treatment without showing signs of fatigue, than the interossei muscles of the hand or an isolated muscle such as the Adductor longus or sartorius.

CASES SUITABLE FOR TREATMENT BY GRADUATED CONTRACTIONS.

It is difficult to classify scientifically cases which are suitable for treatment by the method of Graduated Contraction but they may be for convenience divided into three groups:

Class A. Injuries to muscles and joints which are seen within the first few days - before secondary results have supervened.

Class B. Injuries to muscles and joints which are not seen until later - when secondary results have supervened.

Class C. Fractures.

As before stated, I have for convenience of description confined myself to the use of the word "Strain" as applicable to a muscle, and "Sprain" as applicable to a joint.

CLASS A. Cases seen early.

Muscle Conditions.

1. Simple Strain. (Acute strain).
2. Haematoma in muscle.
3. Subcutaneous wound.

Joint Conditions.

4. Effusion into joint from trauma. (Acute Sprain).

CLASS B. Cases seen late.

Muscle Conditions.

1. Chronic strain.

2. Adhesions in muscles.

3. Muscular wasting from disuse (splints etc.)

Joint Conditions.

4. Chronic effusion in joint from trauma. (Chronic sprain).

5. Adhesions in synovial membrane or peri-articular tissue.

6. Dislocations.

CLASS C. Fractures.

1. Simple Strain. (Acute).

By simple strain is meant an injury to a muscle by which it has been overstretched and has become painful and slightly relaxed.

Such a muscle is painful at some point to pressure, may be slightly swelled, feels soft, and cannot be voluntarily contracted against resistance without pain. Some of the fibres of the muscle may be torn, and bleeding may take place to a more or less

degree, causing later discoloration of skin. Such a condition may recover in a week or so without treatment provided it is not rested, but the muscle usually remains relaxed and does not contract in time with its fellows, so causing slight disability.

By the treatment of a muscle in such a condition by Graduated Contraction, the tone of the muscle is quickly restored, absorption of blood is rapidly promoted, and the pain disappears and the muscle quickly regains its efficiency.

For examples see page 70 Type I cases (a) (b) (c) (d) (e).

2. <u>An injury to a muscle which results in extensive haemorrhage producing a haematoma.</u>

Such a condition quickly recovers by treatment by Graduated Contraction, because the power of absorption is so greatly increased, and the tone of the muscle is restored, so that adhesions and the loss of muscular condition which would rapidly supervene if the injured muscle be kept at rest, are prevented.

For examples see page 74 Type 2. cases (a) (b)

3. <u>An injury resulting in the structure being torn thus causing a subcutaneous wound.</u>

Such a condition, if the injured part be allowed to rest, would without doubt result in more or

less limitation of movement from adhesions forming in the torn structures, and be the seat of pain and aching.

By treatment by Graduated Contractions, absorption takes place rapidly, circulation to the part is greatly stimulated so that healing of torn surfaces is hastened, and the torn surfaces are not allowed to remain at rest in contact with each other, and in this way adhesions are prevented. There is no fear of inflammation taking place, and the muscles do not waste. Recovery is complete and rapid.

For examples see page 76, Type 3 cases (a)& (b)

4. <u>An injury which results in immediate effusion into a joint</u>. (Acute Sprain.)

When a joint receives an injury which results in effusion, the sooner the treatment by Graduated Contractions is commenced the better. The effect is that the muscular contraction squeezes the blood out of the muscles actuating the joint, and forces this blood onwards to the joint, and fresh blood flows into the muscle at each relaxation to be forced onwards in its turn, by the next contraction. Thus the muscles which themselves have been injured, are stimulated and the circulatory changes produced by the free flow of blood to the part, hastens absorption, and prevents stagnation, and the consequent sequelae.

For example see page 78 Type 4. Case (a)

CLASS B. Cases which are not seen until secondary changes have supervened.

1. Chronic Strain. Cases where a simple strain of a muscle has not recovered and the muscle remains disabled from loss of tone with consequent relaxation and wasting.

A muscle or group of muscles may be strained and for many reasons complete recovery does not take place. Partial recovery takes place, that is to say absorption is more or less complete and adhesions do not form, but the muscle does not recover its tone and consequently remains relaxed. In this relaxed condition it is unable to perform its function, thus throwing extra work on the other muscles, and wastingtakes place from disuse. This condition is frequently met with in cases of Rider's Strain, which is a very common injury amongst members of the hunting community, and is perhaps one of the most ideal types to treat by Graduated Contractions, as complete recovery is assured in every case, in a very short time.

For examples see page 79, Type 1 cases (a) (b)(c)(d)(e)(f)(g)

2. Cases in which adhesions form in the muscles so causing limitation of the movement of the part.

In such cases, when the muscle is severely strained haemorrhage takes place into the muscles and sutcutaneous tissue and when absorption does not take place completely, organisation results in the formation of adhesions. The limitation of movement results from the actual binding together of the subcutaneous structures and from the pain produced by stretching the adherent tissues on attempted movement. The muscle or a group of muscles so affected always waste.

The action of Graduated Contractions, besides acting in the manner already described, causes gradual breaking down of these adhesions, a process, which if carried out skilfully, hardly produces any pain, and when the muscles become freed they quickly re-develop and their efficiency is re-established.

For examples see page 85. Type 2 cases (a) (b)(c)

3. Cases of Injury to a joint, such as the knee, where traumatic synovitis has been present for a prolonged period with the resulting wasting of the Quadriceps group of muscles.

Such cases are extremely common and are of the greatest importance because owing to the weakness of the group of muscles and the constant stretching of the capsule from the ever present fluid, the joint becomes loose, and in this flaccid condition it is gradually less able to withstand the stresses to which the knee is so constantly subjected, and thus is frequently the seat of further injuries from slight causes. The looseness of the joint allows so much mobility, that the constant irritation from this laxity encourages the production of effusion, and, further lays the joint open to more serious damage such as dislocation of one or other cartilage. Probably, with a knee in such a slack condition capable of some degree of hyperextension and lateral movement, the thickened synovial membrane, when a sudden movement takes place, is easily "pinched" thus producing sudden pain and further effusion.

By treating the wasted muscles by Graduated Contractions the re-development of the muscles takes place rapidly, circulatory changes are stimulated with the result that the fluid is absorbed and the joint

becomes considerably tightened. As the movement of the muscles functionates the joint, no doubt a form of deep massage results, particularly under the patellar ligament, and in this way absorption of fluid is greatly aided, as it is remarkable how quickly long present fluid disappears when the quadriceps group begin to recover their tone.

For example see page 88, Type 3 cases (a) (b) (c) (d) (e) (f) (g)

4. Injuries to a joint which have resulted in material organic changes such as fibrous ankylosis due to formation of cicatricial tissue in synovial membrane or periarticular tissue. In such cases wasting of the muscles, particularly the extensors of the joint, is usually well-marked.

Sometimes, by re-developing the muscles in a case of this type, the increased muscular power allows a gradually increasing amount of joint movement and so the patient is enabled to break down the adhesions by his own effort. It may, however, be necessary to break down the adhesions under an anaesthetic and commence the treatment by Graduated Contractions at once, so as to hasten the process of absorption. The results obtained in this type of case are most satisfactory.

For examples see pages 93, Type 4 cases (a) and (b)

5. Cases of Muscular Wasting from disuse.

Such cases recover rapidly when treated by Graduated Contraction, as the contractions quickly cause re-development of the muscular tissue. Disuse may be the result of treatment by splints or prolonged rest, or caused by the wrong use, or non-use, of an injured muscle or group of muscles.

For examples see page 95 Type 5 cases (a)(b)(c)

6. Dislocations.

When a dislocation of a joint - such as the shoulder - has occurred the muscles are greatly stretched and remain relaxed and weak for sometimes long periods, allowing the joint to be easily dislocated again.

In such cases Graduated Contractions cause the muscles to recover their tone, and so very materially lessen the chance of re-dislocation, first, from the increased muscular power which results, and secondly because of the confidence which the patient feels which allows him to use the limb in a more natural manner, the various groups of muscles thus acting more completely.

For examples see page 97 Type 6 cases (a)(b)(c)

CLASS C. Fractures.

As fractures form an important group of the cases suitable to treatment by Graduated Contractions, it is a matter for regret that I am not able to incorporate in this work a complete account of the method of application and the results obtained. However, I propose to refer briefly to some of the main points, reserving a fuller description and discussion for a paper which I hope to produce at a later date, as I cannot condider this thesis complete without some reference to such an important group of cases.

In cases of Fractures in which union has taken place, but in which the function of the part has not completely recovered on account of adhesion and wasting, it must be obvious from what has been said, that Graduated Contractions offer a powerful means whereby the function may be quickly restored, in so far as the lost function is due to wasting and adhesions and not to any wrong position of the fractured bone. Such cases are suitable for treatment by Graduated Contractions in the same way as cases of adhesions and muscular wasting from any other cause.

In recent simple Fractures, however, the results already obtained by their treatment by Graduated Contraction have been most remarkable.

Most authorities, as shown by recent litera-

ture, take a pessimistic view of the treatment of Fractures, and the general fact that strikes one on reading the most recent works on Fractures, is, that the cause of the seriousness of a Fracture is the after-effects. Even in cases of simple Fracture where it is possible by skilful treatment to get firm union and perfect apposition of the fragments, the ultimate result is frequently a greatly limited action of the limb, as the result of adhesions and wasting of the muscles, a state of affairs which is in the main part due to the treatment adopted, the chief principle of which is immobilisation. The method of treatment advocated by Professor Lucas Championnière is a distinct advance on the older methods, and, in the hands of those who are skilled in carrying out this treatment, gives results far in advance of the more usually adopted methods. It is undoubtedly a fact that after a bone has been fractured it is seldom possible to get a true restitution of the form of the bone, and further it is not necessary for the restoration of the function of the limb. The "putting up" a Fracture in splints, aims too much at restoring the form of the broken bone and too little at restoring the function of the limb - the function being lost chiefly as the results of this mistaken effort to restore the form viz:- adhesions and muscular wasting.

Various reasons have been given to account for the oedema which quickly supervenes on a fracture and which may become very intense. From my experience of the treatment of Fractures by Graduated Contractions, I am convinced that it is chiefly due to interference with the circulatory system, the loss of pressure on the veins from the loss of muscular contraction possibly retarding the removal of lymph from the tissues.

Mechanical obstruction to the venous return and haemorrhage into the tissues may also act as causative factors and it is also possible that the cause may be vaso-motor in origin.

Whatever be the cause, the fact remains that oedema varying in degree takes place after fracture, and also as the result of any injury to muscle, but, when not caused by a definite mechanical obstruction, quickly disappears when the muscles in the neighbourhood are stimulated to perform their function by Graduated Contractions.

The treatment should be applied as soon after the occurrence of the fracture as possible, as the circulatory changes set up by the muscular contractions are so efficacious that the oedema never becomes intense, and, owing to this increased circulatory effect, reparative changes are rapidly promoted. Another important effect is that when oedema of the

tissues following a fracture is in this manner not allowed to remain, the oedema which usually follows as the result of commencing to use the limb after repair of the bone has taken place, does not occur or only to a slight degree. It has been proved that atrophy of the bone as well as of the muscles, frequently, and probably always, follows prolonged rest and as this result is due to diminution of the blood supply, a means of treatment which so materially increases the amount of blood to the part, is obviously of great use in preventing such bony atrophy.

It is a well known fact that a bone which has a rich blood supply is repaired more rapidly than one in which the blood supply is poor, hence the importance of increasing the amount of blood circulating through a fractured bone.

In proof of this the upper end of a long bone such as the Humerus unites much more rapidly than the middle of the shaft, even although the cross-section of the upper end is greater than that of the shaft, for the reason that the upper end has the advantage of greater vascularity; and a bone like the clavicle which also has a rich blood supply hardly ever fails to unite. The ribs which are rich in their blood supply and which it is impossible to completely immo-

bilise, have never been known not to unite after fracture.

I am able to show by X ray examination of a series of cases, (which I propose to publish at a later date), that the callus forms and ossifies much more rapidly when the fractured limb is treated by Graduated Contractions, than is usually the case when treated by immobilisation, and in this connection it is interesting that even in cases of long standing non-union, the treatment by Graduated Contractions, is followed rapidly by active changes which lead to speedy and firm union. The movements produced between the fragments by the production of muscular contractions should be very slight, and, as the degree of contractions is so completely under control, such slight movements are quite easily obtained.

The effect of such slight and carefully controlledmovements is undoubtedly beneficial in promoting the rapid formation of callus, and the result of operative interference in fractures has shown conclusively that even when a fractured part is absolutely immobilised by plating, repair does not always produce callus of good quality or large in amount. That there need be no fear that the movements of the ends of the fractured bone can do harm if properly carried out, is certain, and results have proved that

it is equally certain that great benefit results from such movement. Lucas-Championnière holds the view that "movement is a fundamental and necessary condition of the life and repair of bone while immobility is detrimental to the proper development of callus."

Although such slight movements may be considered to be beneficial, they can only be so, provided that the chief factor in repair of all fractures is present - i.e. active circulation. Granulation tissue which forms as the basis of true callus, is rapidly produced in a part where the blood supply is good, and this granulation tissue becomes further hyperaemic as the result of the slight movements at the fractured ends, and by the increased amount of the blood which is driven through the part by the pumping action of the contracting and relaxing muscles. Provided that care is taken not to irritate this granulation tissue by excessive movements in the early stages, there is little fear that the granulation tissue will become excessive and so produce excessive formation of callus. This method of treatment by Graduated Contractions of the muscles in the neighbourhood of a fractured bone, acts beneficially in the following manner:-

(1) The contractions, by moving the muscles cause slight movements at the broken ends of the bone,

and these movements cause hyperaemia and increased production of granulation tissue.

(2) The rhythmic contraction of the muscles causes the blood to be forced through the injured part and so absorption of lymph and extravasated blood in the tissues is promoted, and the growth of callus is powerfully stimulated.

(3) The movements of the muscles prevent contiguous muscles and tendons from becoming adherent.

(4) The reproduction of the physiological action of the muscles prevents them becoming atrophied.

For examples see p.99. Class C cases (a) & (b)

SUMMARY AND CONCLUSIONS.

After having spent nine years in specialising in the treatment of injuries to muscles and joints, by a method of treatment called Graduated Contractions, based on the principle of mechanically forcing the muscles and joints to perform their function although injured, I am in a position to state emphatically that such a method gives results far more complete and much more quickly than the older methods of treatment commonly adopted - such as Blistering, the application of Heat and Cold, Pressure, Rest, Massage and Passive Movements.

An experience of many thousands of cases has proved that injuries varying in degree are common to muscles and joints, and unless the injury be very severe, they are so frequently considered of little consequence in the early stage, that disastrous results occur. It does not seem to have been sufficiently recognised by those who should be responsible for their treatment, that a joint is one of the most delicate and complicated structures of the body, and it is astonishing how little attention has been

paid to the mechanical aspect of muscles and joints is so far as such knowledge is essential to the intelligent treatment of injuries to them.

Even when the injury is recognised as serious, it all too frequently happens, that the function of the injured part becomes seriously and permanently interfered with by the still too prevalent advocacy of treatment by "Rest to the Part", and this in spite of the amount of good work which has been carried out by those who preach the doctrine of Massage - a treatment which represents a very encouraging advance on the older and less scientific methods.

Although it is generally admitted that the results of the usually adopted methods of treatment are bad, no effort seems to have been made to devise a better method, and thousands of patients have been condemned to a great deal of needless suffering and disability in consequence.

Partial recovery is a common result of the usual treatment, by Rest etc., and patients are frequently encouraged by those responsible for this treatment, to expect that a part once injured must always remain weak. It has frequently been my experience to see patients in this state of partial recovery, the reason of the weakness being due entirely to wasting of the muscles for which the treatment by Rest was

chiefly responsible.

In the apparatus which produces Graduated Contractions of muscles, I have devised an instrument by the aid of which, the operator is enabled to take control of the injured part, and thereby force it to perform its function, be the part muscle or joint, from a gentle slight movement through the whole range of movements to a maximum, and this, if done properly, does not produce pain and in no single instance has it set up inflammation.

The result of such reproduction of function is that circulatory and chemical changes take place from the increased blood supply, and absorption is thus rapidly promoted, the muscles quickly recover their tone, muscular wasting is prevented, or if present the muscles are quickly re-developed, adhesions are prevented from binding contiguous parts together because such parts are kept on the move, and if adhesions be present, they can be gradually and almost painlessly broken down. Obviously the quickest results of treatment by Graduated Contraction are obtained when the treatment is commenced as soon after the injury as possible, as in such a case, the usual secondary results such as adhesions, and wasting of muscles and oedema are prevented.

Injuries ranging in degree from a slight muscular strain to a very serious damage to muscles and joints are of common occurrence amongst members of the hunting community, and the great majority of my cases during the past nine years have been drawn from this class. Thus I have had a fruitful source from which to obtain cases of injuries of every degree from slight strains to fractures, both in their early state and in the later stages after other treatments have been carried out, and the chief point I am able to emphasise as a result of this experience, is, that the sooner the treatment by Graduated Contraction is begun the better the result from the point of view of completeness and rapidity of cure.

"SUMMARY OF MAIN POINTS."

The following is a summary of the main points of this thesis:-

With regard to Injuries to Muscles and Joints:

(1) All muscles when strained immediately lose their tone and this, by causing impairment of function, is important because of the effect on the muscle viz:- wasting.

(2) This effect on the muscle may be very serious because, if recovery does not take place, the muscle or group of muscles act wrongly or in a limited manner, and the result on the joint is that the transmission of the lines of force through the joint is altered from the normal, and the structure of the articular surfaces is thereby liable to undergo serious changes from unequal pressures.

(3) A joint, the muscles of which are wasted, is for mechanical reasons, frequently the seat of further injury of more or less degree, from slight causes.

(4) All joints, the muscles of which have been injured and in consequence wasted, have their

nutrition interfered with because of the deficient action of the wasted muscles in stimulating the flow of blood through them, and therefore the articular aur-faces are liable to undefgo structural impairment.

(5) The soft vascular tissue which fills up the interstices between the various structures which make up a joint, is peculiarly liable to injury from pressure, and the consequent changes are often liable to cause serious limitation of the function of the joint by the formation of adhesions.

(6) The power to voluntarily enervate a muscle is frequently lost as the result of a very slight injury, and is always lost when the injury is severe.

(7) A patient with an injured joint - even if the injury be slight, - has an unnatural feeling that he "has a joint", and this consciousness leads him to do his utmost to save it, and so the joint be-comes weaker and the muscles are encouraged to waste.

(8) As the result of effusion and haemorrh-age into the tissues, adhesions form very rapidly and when adhesions form in bursae, the result is pain and limitation of movement for long periods.

(9) The various changes such as heat, red-ness and swelling are the result of Nature's efforts to repair the damage done, and although essential to

recovery, the result of the production of these symptoms may be serious if absorption is for any reason delayed.

(10) The treatment by Rest is wrong because it encourages stasis, which in turn delays the process of repair, and promotes the formation of adhesions and wasting of the muscles.

WITH REGARD TO TREATMENT.

1. The object of all treatment should be to increase the amount of blood to the part provided stagnation be prevented, and the injured part should be encouraged to perform its function.

2. The most ideal method is the treatment by Graduated Contractions, and if begun within 48 hours after the injury no secondary results such as adhesions and muscular wasting ever supervene.

3. Rest by immobilisation constitutes improper treatment.

4. It may be necessary by not allowing voluntary movements to enforce rest to a severely danaged part, but the function of the part should be reproduced once daily by Graduated Contractions until voluntary movements are permitted.

5. The method of treatment by Massage and Passive Movements by Skilled operators is superior to the treatment by the application of Heat and Cold, Blistering, and Pressure but the treatment by the Graduated Contraction method is infinitely superior to Massage and Passive Movements.

In the above Thesis, it has been my endeavour to attempt to discuss and explain a new method of treatment for injuries to Muscles and Joints. The work has been full of difficulties and the chief one has been the fact that I have had to attempt to describe in words what would be a simple matter to explain intelligently by a practical demonstration.

To those who have read this thesis, I should esteem it a great favour were I allowed to give a demonstration of the actual working of the apparatus, as I feel convinced that such a demonstration would very quickly and effectively give a clearer understanding of a method of treatment which in my hands has given results in the treatment of injuries to muscles and joints far in advance of any other method of treatment in vogue at the present time.

A list comprising some 40 cases giving the history of injury, condition at the time of commencing treatment by Graduated Contractions and the results

obtained , is appended.

NOTE.

In writing the above thesis, I am greatly indebted to Sir Alfred Pearce Gould, Sir William Bennett, Sir Arbuthnot Lane, Dr. Wharton Hood, Dr. James B. Mennell, Mr. Mansell Moullin, Mr. Whitelocke and Professor Lucas-Championnière for valuable assistance obtained from their various writings.

EXAMPLES OF CASES TREATED BY GRADUATED CONTRACTIONS AND RESULTS.

The following short description of cases is an accurate account of cases taken from a large number which have been treated by me by the method of Graduated Contractions during the past nine years, the classification used being merely for convenience of description.

CLASS A.

Type 1. Simple Strain.

(a) Colonel S. First seen Jan. 1913. While riding seven days ago, felt something "give" at the back of his left thigh on attempting to save his horse from falling. Immediate pain was felt, but he was able to get home by riding very carefully. There was no discoloration but the pain continued and flexing or extending knee was painful. Was massaged and applied antiphlogistine. On examination seven days after injury, the biceps muscle of left leg painful to pressure at junction of muscle and tendon and on attempted flexion against resistance. The muscle felt soft and was obviously relaxed, and bicipital action was weak, and

any determined action painful.

Treatment:- The muscle was treated by Graduated Contractions on two consecutive days for twenty minutes each treatment. Approximately the muscle in these two treatments was contracted about 3600 times, and the patient had no pain or deficient action on the second day and was able to ride etc. in perfect comfort.

(b) F.S. First seen Jan. 1914.

Five days ago, while hunting, jumped over a big fence with a big drop on the other side. On landing, felt great pain in left leg high up in the fork. Pain fairly severe next day but no sign of discoloration. Attempted to ride on the 3rd day when injury was repeated at the first jump and the pain was more severe and more widespread . Still no discoloration.

On examination left adductor longus and sartorius felt soft and painful to touch. Pain on pressure over the attachment of adductor longus. Unable to adduct leg owing to pain and weakness of muscles.

Treatment:- Graduated Contractions applied seven times for twenty minutes each application. Complete recovery.

(c) H.M. First seen July 1912.

Two days ago, while playing tennis felt something "snap" in right calf and this was followed by immediate pain and feeling of helplessness.

On examination, there was faint yellow stain in skin over small area of gastrocnemius, some fibres of which were stained. Slight pain on pressure.

Treatment:- Graduated Contractions for twenty minutes - one application. Complete recovery.

(d) Mr. T. First seen Jan. 1912.

While skating, felt sudden pain at back of right thigh close to knee. Was unable to continue skating. Pain increased next day and leg felt stiff.

Examination: painful point above insertion of biceps on pressure or attempted flexion against resistance. Slight discoloration at lower part of muscle.

Treatment:- Graduated Contractions for twenty minutes for two days. Complete recovery.

(e) A.L. First seen Dec. 1912.

After getting out of motor, patient ran a few steps and felt something catch him in left calf as if he had been kicked. Five days later, when he consulted me, pain could still be elicited by pressure or

attempting to stand on toes, over the inner head of gastrocnemius. No discoloration.

Treatment:- Graduated Contractions applied twice for twenty minutes. Complete recovery.

Type 2.

An injury to a muscle which results in extensive hæmorrhage producing hæmatoma.

(a) Mr. C. First seen July 1912.

Five weeks ago while playing tennis, felt a sudden pain in the front of left thigh and he believed the muscle had broken. Pain very severe and movements such as extension or flexion of knee can only be performed very stiffly and with considerable pain.

Examination: Front of thigh very discoloured and the Quadriceps group of muscles very slack and soft. Patella very movable from side to side owing to laxity of quadriceps. A hard lump felt in the belly of the rectus femoris which is painful to even slight pressure. Leg below knee somewhat œdematous.

Treatment:- Graduated Contractions applied five times for twenty minutes. By the fourth application the hard lump had disappeared and the greater part of the discoloration had cleared up, and the patient could use the limb with perfect comfort.

(b) Miss H. First seen Oct 1912.

Five days ago, while playing tennis, felt a peculiar pricking sensation in the calf of right leg. Calf felt tight and stiff and was painful to use. Same evening, calf was very discoloured.

On examination, five days after accident, calf was indurated and very discoloured down to ankle and œdematous. Hæmatoma in the gastrocnemius.

Treatment:- Graduated Contractions applied daily for 14 applications. Complete recovery.

Type 3.

An injury resulting in the structure being torn, thus causing a subcutaneous wound.

(a) Mr. V. First seen Dec. 1911.

While hunting 12 days ago horse jumped sideways and patient felt severe pain on inner side of left thigh. Was unable to ride and rested leg for 10 days and had massage. Still unable to ride.

Examination: All the skin on inner side of thigh greatly discoloured. The left adductor longus soft and tender to touch. Adduction against resistance very weak and painful to attempt. The muscular tissue of the adductor longus undoubtedly ruptured and probably the tissue of adductor magnus also on account of the severe deep-seated pain on pressure over adductor magnus.

Treatment:- Graduated Contractions applied for twenty minutes on five consecutive days. Complete recovery. Patient able to hunt with perfect comfort after 5th treatment.

(b) Mr. S.J. First seen Dec. 1911.

While riding a few days ago, gripped very hard and strained muscle on inner side of right thigh. Great pain at once, aggravated by walking, or attempt-

ing to grip, and quite unable to attempt to get on a horse. Extensive discoloration.

Examination: Inner side of right thigh discoloured down to knee - a deep claret colour. Just below the origin of adductor longus the tendon is greatly thickened and very painful on pressure. Adductor longus very relaxed.

Treatment:- Graduated Contractions carried out daily for 10 days. Complete recovery.

Type 4.

An injury which results in a large amount of effusion into a joint.

(a) General A. First seen July 1913.

Two days ago, while getting out of a train, felt a slight pain in left knee. Played tennis that afternoon and on waking next morning knee felt stiff and was swelled. Some lateral or twisting movements caused slight pain.

Examination: Knee joint distended with fluid and quadriceps group of muscles very relaxed. Patella easily movable in all directions.

Treatment:- Graduated Contractions applied for twenty minutes to half-an-hour eight times. Complete recovery and able to play tennis at end of week.

CLASS B.

Cases not seen until secondary changes have supervened.

Type 1.

Chronic Strain: Cases where a simple strain of a muscle has not recovered and the muscle remains disabled from loss of tone with consequent relaxation and wasting.

This group comprises a large number of cases of a condition well known amongst the members of the hunting community as "Rider's Strain"; several examples of the various types are here given.

(a) Mr. E. First seen Sept. 1913.

Five months ago while collecting a horse which stumbled, felt sudden severe pain in the right leg high up in the fork. On dismounting, leg was very stiff and painful on walking. Was unable to ride owing to pain, so rested for ten days, and had massage and liniments applied. No discoloration appeared.

At the present moment, although five months since time of accident, patient is unable to ride because of his inability to grip, and any great effort to do so causes pain. He is also not able to flex his thigh on his abdomen with ease or comfort.

Examination: Sartorius and adductor longus are both soft to touch, and markedly wasted. On attempted adduction against resistance, pain is produced in the neighbourhood of the attachment of the adductor longus.

Treatment:- Graduated Contractions applied for twenty minutes for 15 days. Complete recovery.

Pain entirely disappeared by the end of first week and when the patient returned home on completion of treatment he was able to grip strongly and with no pain, and consequently could ride again with comfort.

It is interesting to note that the actual number of times the injured muscles in the above case were forced to contract during the treatment was approximately 27,000 (Twenty Seven Thousand).

(b) Mr. J. First seen Jan. 1912.

Three weeks ago horse slipped as he took off at a jump and patient was thrown forward but was not thrown off. In the great effort to hold on, he injured left leg on inner side of thigh - great pain, felt sick and perspired freely. Is still unable to ride owing to pain and inability to grip. No discoloration noted.

Examination: Adductor longus soft and wasted, and a hard indurated lump in the tendon of origin which

is painful on pressure.

Treatment:- Graduated Contractions applied seven times. Complete recovery.

(c) Mr. G.C.O. First seen Nov. 1911.

Five weeks ago while riding strained right leg and felt immediate severe pain in inner side of right thigh. Unable to grip. No discoloration. Stiffness on attempted movement very marked.

Examination: Right adductor longus wasted, relaxed, and painful on attempted adduction or on effort to cross leg over the other. In this case, the wasting was very slight, and the inability to grip was almost entirely due to the relaxed state of the muscle.

Treatment: Graduated Contractions applied for twenty minutes on two occasions, the muscle being contracted about 4000 times, the effect being to considerably tighten the relaxed muscle and so allow it to work synchronously with its fellows. Complete recovery. Patient able to ride on second day.

(d) Captain P. First seen Dec. 1912.

14 days ago, while jumping felt sudden severe pain in left leg, inner side of thigh, high up. Rode on for a little, but pain became very severe and patient was forced to drive home. Discoloration ap-

peared extending down the leg and in spite of rest and lotions and massage; the leg became stiff and painful on movement.

Examination: Adductor longus relaxed, thickened below tendon of origin, painful at this point to deep pressure and wasted.

Treatment:- Graduated Contractions applied for twenty minutes once daily for 8 days. Complete recovery.

(e) Miss G. First seen May 1912.

Two months ago fell from horse and had immediate pain in her back which increased in severity a few hours later. Pain chiefly on left side and greatly aggravated on movement. Rested for some days and lotions applied. Pain got gradually less, but any effort at violent exercise, such as tennis, or even sitting for long in one position, produces stiffness and continual aching. Unable to ride etc.

Examination: Left erector spinae muscle markedly wasted and soft to touch. No pain on pressure.

Treatment:- Graduated Contractions applied daily for twenty minutes for 20 days. Result: Complete recovery. Patient now able to hunt and play tennis and never feels any discomfort.

(f) Miss T. First seen May 1913.

History of a fall 5 years ago but details indefinite was supposed to have injured her back and was treated by spinal exercises. Ever since, patient has had a "weak back", and violent exercise or prolonged standing causes pain and a feeling of great tiredness which is so constant an occurrence that patient has to rest a great deal. Pain disappears on resting, particularly on lying down. Has had various treatments and consulted many authorities, many of whom have considered pain due to kidney trouble.

Examination: Right erector spinæ markedly wasted and soft.

Treatment:- Graduated Contractions applied once daily for 10 days and 8 times over period of 3 weeks - 18 applications in all.

Result: No recurrence of pain even after severe exertion.

(g) Miss P.B. First seen May 4th 1911.

About 15 years ago horse ran into railings and fell and rolled over patient. No immediate effect beyond stiffness in back. Gradually patient became aware that severe exercise such as riding, or much standing produced pain in her back and this condition has gradually become worse so that patient is unable to

ride at all, and has to rest a great deal. Four years ago, pain said to be due to a floating kidney which was operated upon, but, although better for a time, probably due to the long rest, the condition is as bad as ever.

Examination:- Right erector spinæ very inefficient from wasting. Feels soft and doughy, and looks markedly smaller than left.

Treatment:- Erector spinæ treated by Graduated Contractions for twenty minutes daily for twenty-one days. Complete recovery. Patient now has no pain and rides, plays tennis, and rows.

These three cases of injury to the erector spinæ muscle are examples of what is from my experience a very common injury, which produces a considerable amount of pain and disability and injury to the general health. The condition is not generally recognised and the pain is frequently considered to be due to kidney condition.

Type 2.

Cases in which adhesions form in the muscles so causing limitation of movement of the part.

(a) Mr. G.T. First seen May 1913.

Fell, while hunting, 6 weeks ago, and struck point of left shoulder. Immediate pain, swelling, and inability to move the arm. Became very discolored Was massaged daily. Very painful at the point of insertion of deltoid tendon.

Examination:- Deltoid muscle very wasted and indurated. Is painful on deep pressure, particularly over point of insertion. Faint yellowish discoloration still noticed. Triceps and biceps also wasted. Rotation of humerus complete and arm can be raised but not by patient's own efforts.

Treatment:- The wasted muscles were redeveloped by Graduated Contractions applied once daily for twenty minutes for 16 days. The adhesions in the deltoid muscle were gradually broken down and the normal action of the muscle recovered and movements became complete and painless.

(b) Mr. B. First seen July 1913.

Three weeks ago, while playing cricket, at the moment of commencing to run felt pain in calf of his left leg and thought some one had struck him. Strapped leg with adhesive plaster and continued to play, but could not run. Kept it strapped up for 14 days and used leg carefully, and on the 15th day tried to play cricket again, but was unable to do so on account of the pain. Leg was discoloured and painful on deep pressure.

Examination:- In the centre of gastrocnemius, there is a painful area, which feels hard, and on attempting to dorsiflex the foot, becomes stretched and painful. Patient's efforts to rise on toes, produces similar pain. There are well marked adhesions in the gastrocnemius, due to the tearing of the fibres by the original strain, and the subsequent rest allowing the torn surfaces to heal in an irregular manner.

Treatment:- The adhesions were gradually broken down by the application of Graduated Contractions applied daily for twenty minutes, twenty-one times.

Result:- At the end of that time, patient was able to perform every movement of the foot and leg without pain, all discolouration had disappeared, and the muscle was not wasted.

(c) Mr. F. First seen Dec. 1912.

Acute sciatica of right leg five months ago. Acute pain now gone, but great limitation of the movements of the ankle and knee. Cannot extend the leg or dorsiflex the foot without causing pain which patient describes as a feeling that the muscles were being stretched.

Examination:- Muscles of thigh and leg wasted and smaller than those of the left leg, and on any attempt to extend leg at knee, the muscles at back of thigh feel overstretched and become painful. Dorsiflexion at the ankle, produces similar symptoms in the calf.

Treatment:- The muscles were stimulated by Graduated Contractions and the adhesions gradually broken down and the muscles re-developed. After daily treatment of twenty minutes duration for 34 days, the patient had recovered complete and painless use of the leg and was able to walk and run with ease. The size of the leg recovered to the size of its fellow.

Type 3.

Cases of injury to a joint, such as the knee, where traumatic synovitis has been present for a prolonged period with resulting wasting of the Quadriceps group of muscles.

(a) Mr. W. First seen Sept. 1911, age 61.

Twenty years ago sprained right knee at football and has repeated the injury repeatedly ever since. Five years ago had similar injury to left knee by slipping and now both knees are a constant trouble and patient is only able to go about with the greatest care. Has given up all games.

One or other knee gives way suddenly, swelling quickly supervenes, but there is little pain beyond a feeling of tightness in the muscles behind knee, and great stiffness.

Examination:- Some fluid in right knee and the quadriceps greatly wasted. Knee joint is loose and allows of considerable lateral movement. No pain over internal semilunar cartilage. Left knee in similar condition but there is no fluid.

Treatment:- The quadriceps groups of both knees were treated by Graduated Contractions for full half hour daily - each group receiving approximately 15,000 contractions at each application. The treatment was

carried out 12 times, the total number of contractions thus approaching 18,000 for each group and the patient then returned home for 3 weeks and carried out exercises himself. At the end of that time, he reported that his knees felt remarkably strong and he has since had no synovitis or feeling of his knees giving way. Last report 1914.

(b) Mr. H.W. First seen Jan. 1913. Age 19.

Said to have slipped left semilunar cartilage 2½ months ago. Was unable to straighten knee for 5 or 6 days. Knee was greatly swelled, and painful on any sudden movement. Leg feels very weak and gives way easily.

Examination:- Left knee is considerably swelled, does not feel hot, and is not painful to touch at any point. Quadriceps group considerably wasted and soft. All movements of joint complete and painless. Knee joint is loose and allows of considerable lateral movement.

Treatment:- Quadriceps group treated daily for 25 minutes by Graduated Contractions for 10 days. Approximate number of contractions 22,500.

Result:- quadriceps group recovered tone and firmness. Size nearly equal to other leg. Fluid disappeared entirely and patient able to play games with confidence.

(c) Mr. L.B.McC. First seen Jan. 1913.

Three weeks ago was kicked at football on left knee. Swelled next day and painful to bend. Feels stiff after sitting.

Examination:- Fluid in joint, flexion incomplete and painful, quadriceps wasted.

Treatment:- Treated by Graduated Contractions for 12 days. Approximate number of contractions 22,800.

Result:- Fluid absorbed, muscles recovered and patient able to use leg as well as ever.

(d) Miss M. First seen Sept. 1911.

Three months ago, fell down stairs and injured left knee. No swelling until a week later, but knee felt weak and painful. Knee was never locked.

Swelling became severe and patient rested with a posterior splint for 3 weeks.

Fluid disappeared as result, but on again walking, knee was very weak and easily gave way, and fluid returned in two days. No pain.

Examination:- Fluid in joint and great wasting of quadriceps muscles.

Treatment:- Graduated Contractions for 25 minutes daily, 26 applications. Approximate number of

contractions 61,650.

Result:- Fluid rapidly became absorbed, muscles redeveloped and patient able to do all movements of leg with perfect confidence.

(e) Miss N.L. First seen April 1911.

Two months ago, twisted left knee while skiing in Switzerland, and the knee swelled that evening. Knee was not locked and pain not very severe, but stiffness was considerable. Rested with knee tightly bandaged for 12 days and had massage. Now cannot do very much, as knee easily gives way, feels stiff, and frequently swells.

Examination:- Fluid in joint, wasted quadriceps with lateral movement of knee.

Treatment:- Graduated Contractions for 17 days. Approximate number of contractions 30,600.

Result:- Complete recovery.

(f) Mr. H.G. First seen Sept. 1912.

Had fluid in right knee two years ago which recovered after prolonged treatment at Bath. Recurred 9 months ago, and been present ever since. No history of injury. Patient weighs over 19 stone. Knee gives way easily and patient nervous about coming down stairs or crossing road in traffic. Left knee never given trouble.

Examination:- Knee joint greatly distended with fluid. Quadriceps wasted. No painful point. Extension complete. Flexion incomplete on account of tension from fluid.

Treatment:- Graduated Contractions for twenty minutes daily for 13 days - approximate number of contractions 26,000.

Result:- Complete recovery. Patient saw me in Feb. 1914 and reported no recurrence.

(g) Captain D. First seen June 1912.

One and half years ago injured right knee at football and was reported to have torn the ligaments. Knee has given trouble ever since. It feels weak, , frequently swells, aches after use, and feels stiff on rising in mornings.

Examination:- Knee cap very freely movable laterally, quadriceps wasted $\frac{5}{8}$ of an inch and slight amount of fluid.

Treatment:- Graduated Contractions for twenty minutes for 9 days.

Result:- Quadriceps increased in size and tone and knee has given no further trouble (1914).

Type 4.

Injuries to a joint which have resulted in material organic changes such as fibrous ankylosis due to formation of cicatricial tissue in synovial membrane or periarticular tissue. In such cases wasting of the muscles, particularly the extensors of the joint is usually well marked.

(a) Major L. First seen October 1911.

Twelve weeks ago, fell hunting, and was thrown against a stone wall, striking it violently with left shoulder. Right arm was amputated at shoulder during S. African war. Great pain in shoulder and was unable to move shoulder joint. Shoulder swelled same night, and pain became acute. Arm was strapped to side for 3 weeks and movements were commenced, and pain again became severe.

Examination:- Great limitation of movements in all directions and considerable wasting of all muscles of shoulder girdle and arm. No rotation of head of humerus. Stereoscopic X-ray photo showed fracture of glenoid cavity at lower margin.

Treatment:- Adhesions broken down under an anæsthetic and Graduated Contractions begun two days later. Contractions continued daily for twenty minutes, 31 treatments being given. Approximate number of con-

tractions 55,800.

Result:- Complete recovery of movements in all directions. As this patient had only one arm the importance of the result obtained is obvious

(b) Mr. T. First seen October 1911.

Four months ago fell down stairs and injured right arm. Considerable pain in joint and swelling noticed that night. Pain extended down to elbow. Pain gets less if arm kept still.

Examination:- Deltoid,Biceps and Triceps muscles wasted and feel soft and flabby. Movements in the shoulder joint restricted in all directions but particularly backward and rotation movements.

Treatment:- Adhesions broken down and treatment by Graduated Contractions begun next day, for twenty minutes each day for 23 days.

Result:- All wasted muscles re-developed and movements in all directions returned.

Type 5.

Cases of muscular wasting from disuse.

(a) Mrs S. First seen May 1913.

Aouut 5 years ago slipped cartilage in right knee and was laid up with splint for a month, on account of fluid in joint, and pain. During this period, did not walk at all. On beginning to walk, knee felt weak and insecure, giving way on slightest movement if great care not taken. Aches when tired.

Examination: no fluid, perfect extension and flexion, but excessive lateral movement. Patella very easily moved laterally. Quadriceps one inch smaller in girth than left.

Treatment: Treated daily for 25 minutes for 14 days by Graduated Contractions.

Result: Complete disappearance of all symptoms and patient able to use leg as well as other.

(b) Mr. S.S. First seen December 1911.

Four years ago slipped cartilage of left knee. Rested for one month with splint and bandages. Knee has felt weak ever since and is painful after severe exercise such as shooting over rough ground. Is often stiff after sitting.

Examination: Patella freely movable in all directions and thigh $\frac{1}{4}$ of an inch smaller in girth

above knee than right.

Treatment: Advised exercises with view of developing Quadriceps - this carried out for six weeks with little benefit.

Patient returned and Graduated Contractions applied for 20 minutes daily for eight days.

Result: Complete recovery and no trouble with knee since (1914)

(c) Mr G. First seen 1911.

Nine months ago injured left knee playing golf and after various treatments including prolonged rest, knee became so weak and loose that patient could only walk with a knee apparatus.

Examination: Knee loose and easily moveable laterally. Patella very slack and Quadriceps group of muscles weak and flabby, the girth of thigh above knee being $\frac{7}{8}$ of an inch less than fellow.

Treatment: Muscles treated 28 times for 25 minutes by Graduated Contractions.

Result: Complete use of leg resulted and patient has had no further trouble (1914).

Type 6.

Dislocations.

(a) Mr A. P. First seen May 1908.

On December 26th 1907, had fall from horse resulting in dislocation of left hip. Was reduced six hours later and the pain disappeared in a few days. Was allowed up on crutches 3 weeks later, but attempts at walking were a failure because of the weakness of the leg and feeling of insecurity at joint.

Examination: Girth of left thigh at 11 inches from head of fibula one inch smaller than right, and at 8 inches from head of fibula 1½ inches smaller than right.

Treatment: Graduated Contractions carried out daily for 20 minutes for 30 treatments.

Result: Complete recovery. One month after treatment girth at above two points was very slightly less than in right leg. Patient was able to take on the Mastership of a pack of hounds and hunt four days a week in September 1908.

(b) Miss H. First seen November 1912.

Eighteen months ago dislocated right shoulder. Strapped up for 3 weeks and was stiff and weak afterwards. Gradually got stronger but never felt very secure. Fourteen days ago, dislocated it again.

Strapped up for 6 days and now patient says it feels "too moveable" and thinks it slips when she uses it. Feels very weak and aches a great deal.

Examination: All muscles of shoulder girdle - particularly deltoid - are flabby and wasted.

Treatment: Graduated Contractions applied 8 times Patient seen 11 months after for another injury when she reported shoulder completely recovered and that she was able to play all games with comfort.

(c) Mrs G. First seen July 1912.

About 12 years ago first dislocated left shoulder as result of hunting accident. Since then shoulder has repeatedly been dislocated, sometimes from simple causes such as a sneeze which caused dislocation last week. Has been "out" over 20 times. Moves arm always through a slight range.

Examination: All muscles of shoulder girdle very wasted, particularly Deltoid.

Treatment: Graduated Contractions applied daily for 25 minutes for 24 days. Approximate number of muscular contractions 65,000.

Result: Muscles recovered size and tone and arm capable of movements in all directions without feeling of insecurity. No recurrence when last heard of in January 1914.

CLASS C.

Fractures.

In the following examples of Fractures treated by Graduated Contractions, I am only giving two typical examples of fractures, in which treatment was begun almost immediately, i.e. before union had commenced. In cases of Fractures seen at the later stages, the benefit from the treatment is due to the power of re-developing wasted muscles and breaking down adhesions, examples of which have already been given, although not in connection with fractures.

(a) Master E. M. Age 16. First seen December 4th 1913.

Seven days ago a fall in gymnasium caused fracture of lower end of radius and ulna with bad displacement. Set at time and put in splints.
X ray photograph taken on December 4th (7 days after accident) showed the bones to be displaced forwards forming an angle at the fractured ends.
December 5th, fracture re-set under anaesthetic.
Two days later all the muscles of the forearm were carefully contracted without removing splint. It is possible to do this without moving fractured ends to any degree. On the third day treatment repeated without splint and continued daily till Dec. 15th - 8 days.
On 9th day X ray photograph taken which showed a fair amount of healthy callus.

December 17th splint permanently removed and on December 20th patient played golf. Pronation and supination complete and patient able to grip powerfully.

(b) Mr R. First seen September 15th,1913

Impacted fracture of surgical neck of humerus and fracture of great tuberosity produced by fall on September 13th. Great bruising of deltoid. X ray taken September 15th which confirmed diagnosis.

Treatment: Graduated Contractions applied daily commencing September 15th for 25 minutes, beginning with very slight contractions in all muscles of shoulder. Bruise gradually extended down forearm and disappeared by the 9th day.

On 5th day arm was carefully moved to a right angle with trunk.

On 12th day patient voluntarily moved arm to right angle.

On 29th day was able to play golf with full swing without pain, and with perfect ease.